



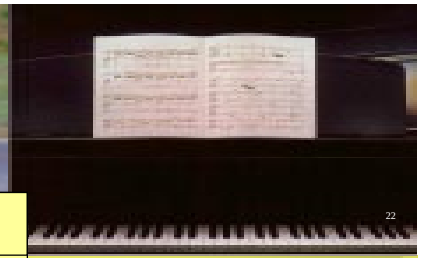

# Mechanics

## Definitions

Fundamental Quantities: x [meters] m [kilograms] θ [radians] t [seconds]

**Linear Motion**

$\vec{v} = \frac{d\vec{x}}{dt}$ — The **velocity v** of an object at position **x**.

$\vec{a} = \frac{d\vec{v}}{dt}$ — The **acceleration a** of an object moving with velocity **v**.

$\vec{p} = m\vec{v}$ — The **momentum p** of an object of mass m moving with velocity **v**.

$\vec{F} = \frac{d\vec{p}}{dt}$ — The **total force F** acting on an object with momentum **p**.

**Angular Motion**

$\vec{\omega} = \frac{d\vec{\theta}}{dt}$ — The **angular velocity** ω of an object at angle θ.

$\vec{\alpha} = \frac{d\vec{\omega}}{dt}$ — The **angular acceleration a** of an object moving with angular velocity ω.

$\vec{L} = \vec{r} \times \vec{p}$ — The **angular momentum L** of an object of momentum **p** at position **r** with respect to the origin.

$\vec{\tau} = \vec{r} \times \vec{F}$ — The **torque** τ on an object subjected to a force **F** applied at position **r** with respect to the origin.

$I = \sum_i m_i R_i^2$ — The **moment of inertia I** of a system composed of objects of mass $m_i$, each a distance $R_i$ from the axis of interest.

**Energy**

$F = -\frac{dU}{dx}$ — The **potential energy U** giving rise to a force F(x)

$T = \frac{1}{2}mv^2$ — The **kinetic energy T** of a point object of mass m moving with velocity v.

$P = \frac{dE}{dt}$ — The **power P** imparted to a system with energy E

## Observations

For any two objects of mass $m_1$ and $m_2$,

$$F = \frac{Gm_1m_2}{r^2}$$

For some objects ("springs"), $\vec{F} = -k\vec{x}$

For some pairs of surfaces, $F_{f_k} = \mu_k F_N$

For some pairs of surfaces, $F_{f_s} \le \mu_s F_N$

For some physical systems, we can neglect all other forces.